Discussion Draft

Developing Strategy for Waterborne Microbial Disease

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INTRODUCTION

The Safe Drinking Water Act (SDWA) and the Clean Water Acts (CWA) address microbial contamination of the nation's waters. The CWA enables protection of surface water for drinking water, recreational, and aquatic food source uses. The SDWA enables regulation of contamination of finished drinking water and protection of source waters. Programs under the two Acts have historically followed separate paths using differing indicators of contamination and approaches. Concerns about future increases in microbial contamination and potential for emergence of new threats create a need to consider a strategy for the future that unites the influence of the two programs. Objectives of the strategy are to address all important sources of contamination, anticipate emerging problems, and use program and research activities efficiently to protect public health.

As an EPA strategy develops, it will have many stakeholders and partners. An important part of the EPA strategy will be the cooperative engagement of the programs and research of states, tribes, other federal agencies and departments, and private entities.

THE WATERBORNE MICROBIAL PROBLEM

Everyone uses water – for drinking, cooking, bathing, farming, recreation and many other purposes. Some water uses and natural processes result in microbial contamination of source waters. These waters are increasingly impacted by the dramatic rise in human and animal populations and their resulting body excretions or "waste", resulting in the impairment of 21,000 waterbodies. Animal excretions enter source waters from a variety of sources including sewage treatment, septic tanks, animal feeding operations, and run-off from urban and rural land. For people to use source waters for drinking, they generally must be treated, which often involves the addition of chemical disinfectants. Water treatment can result in the formation of disinfectant by-products, chemicals which have been associated with adverse health effects. In order to maximize health protection for drinking water, it is necessary to optimize microbial control while keeping potentially hazardous by-products at a minimum. This is becoming increasingly costly and a stress on our water treatment infrastructure.

The consequences of microbial water contamination are severe. On a worldwide basis, the disease most likely to result in child mortality is diarrhea, with an incidence rate of 2.6 episodes per child per year and a global mortality estimate of 3.3 million deaths per year (Bern *et al.* 1992). The most common source of pathogenic diarrhea-causing organisms is contaminated drinking water (Baqai 1988, Czachor 1992). Children are often more susceptible to microbial diseases than adults because they have not yet acquired the protective microbial immunity that adults have. On a per weight basis, children consume more water and food than do adults, and thus may have higher exposure. Once they get a disease, they are more likely to die of dehydration. U.S. communities have experienced the consequences of contaminated water – localized epidemics of gastrointestinal distress with some deaths.

Contamination by both human wastes and by animals

can contribute to human disease.
Historically, the interaction between humans and animals has been a major source of human microbial disease. As humans have domesticated animals and populated previously pristine and rural areas, increased interaction has resulted in the evolution of new human pathogens; that is, microbes which previously had animals hosts have acquired the ability to infect humans (zoonotic transfer). Table 1 contains a few of the many examples of this phenomenon.

Table 1. Animal to human microbial transfer (zoonosis) resulting in disease.

Animal host	Human disease
Bird	**Salmonellosis, Campylobacter (Psittacosis)**
Cats	**Toxoplasmosis, Tularemia,**
Cattle	**Cryptosporidiosis, Giardiasis, E. coli**
Deer	**Anthrax, Brucellosis, Leptospirosis**
Horse	**Brucellosis, E. coli, Salmonellosis**
Swine	**E. coli, Glanders, Giardiasis**

Increases in human, livestock population and wildlife, increase in the number of structures that impact the environment (such as dams), deforestation, suburban expansion and increased international travel and trade – all may have an impact in the proliferation of emerging pathogens and increases in the incidences of infections.

Microbes evolve rapidly; they adapt to their environment by developing traits which can make them more effective parasites or pathogens. It is likely that innovative approaches will need to be developed to ensure that the many uses of water do not result in exposure to disease-causing organisms.

Protection of source waters is necessary to provide or maintain high quality ambient waters that are swimmable and fishable and to manage watersheds more effectively so that we can reduce the burden on drinking water sources.

CURRENT WATER PROGRAM ACTIVITIES AND POTENTIAL FUTURE NEEDS

The EPA is responsible for implementing the CWA, the SDWA, as well as portions of other statutes affecting water quality, such as the Coastal Zone Reauthorization Amendments of 1990, the Ocean Dumping Ban Act, and the Marine Protection Research and Sanctuaries Act. EPA programs have been effective in both reducing the microbial burden of waters and ensuring effective limitation of human exposure (for example, through water disinfection standards). Since EPA's inception in 1970, implementation of regulations and programs has significantly improved surface water quality and ensured safe drinking water. For example, as a result of actions taken under the Ocean Dumping Ban Act and the CWA, industrial waste and biosolids (sewage sludge) are no longer dumped directly into U.S. coastal waters. Compliance with standards under SDWA will ensure safer drinking water supplies and better public health.

Building on these significant strides, EPA continues to reduce water pollution sources such as pollutant runoff from agricultural lands, anumal feeding operations, stormwater/urban runoff from cities, and seepage into ground water from a wide range of origins. Although there have been overall improvements in the Nation's

waters, microbial contamination of recreational waters, fishing and shellfish growing waters, and of drinking waters still presents problems in many communities. Table 2 and 3 reflect the needed actions based on existing EPA programs. This strategy will address some of these problems.

GOALS

Public Health Goal

Protection of public health from exposures to harmful levels of pathogens in ground and surface waters, food sources, and finished drinking water.

Strategic Goal

Setting priorities for the future by:

< Providing an integrated, approach to protection of public health.

< Reducing human exposures to pathogens in our waters:
- reducing sources of contamination through:
  — enhancing ongoing programs
  — new actions
- reducing exposures from:
  — drinking water
  — recreational, shellfish and other ambient waters

< Providing:
- programs and priorities
- regulatory and voluntary actions
- tools and research programs to accomplish goals

APPROACHES

Under SDWA and CWA, the Office of Water (OW) has established an approach that is organized around the risk assessment/risk management paradigm (Figure 1). This draft assessment has six parts: hazard identification; contamination assessment: exposure assessment; data collection and analysis; dose response assessment; and risk management.

In the following section we describe the top four approaches to water protection which include both limiting water contamination and limiting exposure. We will also describe the objective(s) needed to accomplish the approach.

Ambient Water Quality Criteria (AWQC):

Objectives:
< Develop ambient water quality criteria and monitoring protocols for pathogens in drinking source waters.
< Reduction of risk of disease to users of the nation's recreational waters
< Update growing water criteria for shellfish-growing-waters to better protect consumers from pathogens associated with raw shellfish.

The following three Action areas cover the programs to establish improved ambient water quality: **Drinking Source Water Quality Criteria, Recreational Water Quality Criteria, and Protection of Shellfish Growing Waters.**

EPA currently has AWQC and risk-based indicators of fecal contamination for protection of recreational water uses. The Agency has a program to address a shortcomings and gaps in protection afforded by the

criteria for recreational waters – the Action Plan for Beaches and Recreational Waters. EPA has also issued guidance on allowable fecal indicator discharge levels upstream of shellfish growing waters and criteria/fecal indicators for shellfish growing/harvest waters; these address sewage treatment plant effluent quality. Collectively, these criteria/guidance are designed to protect the public against harmful exposures to infectious disease organisms consistent with the designated use of the waters. However the criteria and indicators for each of these water uses are different from each other. Furthermore, the Agency does currently not have protective criteria or indicators of fecal contamination for determining the quality of ambient waters intended for drinking and other household uses. OW's goal for the future is to have an integrated, coordinated approach to risk based criteria. This will be based on exposure, and the application of a common set of fecal indicators across the various uses of water, rather than different indicators for specific uses. As new health protective criteria and indicator/monitoring requirements are developed for ambient water uses we will ensure that they are uniform, consistent, and rational across uses.

Contamination Sources

Objectives:

- Establish model management practices and develop technical and programmatic guidance for managing on-site wastewater systems (OWTS) that are commonly referred to as septic systems.
- Provide guidance on how best to implement "smart growth" to protect water quality, wildlife habitat and human and domesticated animal health.
- Establish model management systems and techniques for controlling nonpoint/diffuse sources of pollution.
- Enhance current program integration to control point sources of microbial pollution and understand their relative contributions to receiving waters.

The two primary sources of pathogenic contamination of water bodies are: 1) diffuse or non-point source, which include agricultural and urban runoff, OWTS (septic tanks) and new developments (changes in land use such as residential sprawl), and 2) point sources, which include sources such as Combined Sewer Overflow (CSO), Sanitary Sewer Overflow (SSO), Publicly Owned Treatment Works (POTW), concentrated animal feeding operations (CAFOs), and storn water from entities subject to the NPDES permit program requirements.

On-site wastewater treatment systems, typically septic systems, and alternative on-site treatment technologies, are not uniformly regulated. Poorly designed, poorly built, and/or poorly maintained on-site systems often fail and can be significant sources of contamination. Fecal contamination from these systems often occurs, and studies have shown that viruses, microbial indicators, and chemical tracers originating from these sources can travel significant distances through and over soil and can end up in surface and ground waters. Typically local and State authorities do not monitor the condition of septic tanks, disposal fields or other components of these systems, and investigate only when failures are brought to their attention. Water resources impacted include public and private drinking water sources, recreational waters, and shellfish waters. Estimates indicate that at any given time at least 10% to 30% of existing septic systems are significantly failing.

Other Water Uses and Discharges

Objective: Establish treatment requirements or protective discharge criteria and monitoring requirements for reused waters and unregulated industrial wastes.

Direct water reuse and unregulated/under-regulated industrial waste discharges of infectious disease agents have potential to pollute waters. Land application of wastewater, treatment sludge (including biosolids), and industrial waste sludge also have potential for contributing residual pathogens to ambient waters through leaching or runoff.

Waste water effluents from various sources (e.g., municipal and industrial effluents, storm waters) are reused as a water source for many purposes – including industrial cooling water; source water for creating/maintaining wetland habitat and recreation areas; groundwater recharge, irrigation of food, forage and fiber crops; urban landscape irrigation; industrial processing; and augmenting potable surface and groundwater source waters. These wastewater effluents may contain pathogens at levels that can impact intended water uses, including irrigation. With increasing pressures on water resources for both human activity and protection of ecological habitats, local communities are looking more frequently at water reuse to supplement these resources, especially in the arid southwest and the southeast. Currently, criteria for microbiological quality of publicly owned treatment works (POTW) wastewater discharge do not reflect the potential impacts to downstream drinking water intakes. Furthermore there are no requirements to notify downstream users when discharges exceed limits due to accidents or upsets in the system. We also lack national standards on the microbiological quality of shipboard "grey water" and other vessel discharges of pathogen laden pollutants near our shores.

Risk Assessment–microbial paradigm

Objective: Establish an EPA Risk Assessment Forum panel to document a microbial risk assessment paradigm.

The public health community has long relied on the National Academy of Sciences risk assessment paradigm for assessment of chemical health risk potential. This assessment protocol has four parts: hazard identification; exposure assessment; dose response assessment; and risk characterization. The fit of this paradigm to microbiological risk assessment is imperfect; there are additional considerations for an environmental contaminant that is a living thing. Pathogens may grow or die in water. They can mutate and thus become more pathogenic, express toxins and other virulence factors. Different strains of the same species can have varying potentials to infect and to cause disease. Human susceptibility and health effects manifestations upon infection may also be quite variable depending on the age, pre-existing immunity, and general health of the exposed population. Furthermore, once infected, a person may spread certain infectious diseases to others (secondary spread) or may suffer from serious aftereffects of disease (chronic sequelae). Appropriate risk assessment protocols for waterborne infectious diseases would increase the accuracy of assessments used for developing regulations, prioritizing enhancements to public health protection, and for conducting outbreak investigations.

Further Areas of Concern

In the following section we describe other areas that

are under consideration and for which further discussions are needed.

Pathogens in Sediments

Programs are in place to regulate discharges of chemical and biological wastes, and guidelines exist for evaluation of contamination potential from discharges. However, we do not have similar programs or guidelines to regulate or evaluate microbiological impacts of pathogens in sediments. Pathogens released from sediments pose a potential water quality risk that must be assessed. Fecal pathogens (and indicators) that normally die out within a few days in ambient water environment are known to survive for much longer periods when embedded in fecal material. Sediments also serve as a sink for pathogens (and indicators) from the water column, especially when they are attached to feces, soils, and clay particles that enhance the settling out process. A few studies have shown that particulate associated pathogens may survive for months or even years in bottom sediment under certain conditions.

Ecosystem Microbiology

Microorganisms represent a large and important biotic component of aquatic ecosystems. They are members of the primary trophic level in the food chain and are an essential component for the health and maintenance of all ecosystems. Microbes are responsible for the biogeochemical cycling of primary nutrients including carbon, nitrogen, phosphorous, and sulfur. Natural and anthropogenic stressors (including microbes themselves) may adversely and directly affect aquatic ecosystems by altering microbial community structure and function. Furthermore, input of microbial pathogens of human and animal origin alone or in combination with others stressors to aquatic systems may have adverse effects on human and ecosystem health. Our understanding of sources, transport, and survival of microbial pathogens and their impact on human and ecosystem health is limited.

Risk from animal-borne pathogens

The risk of human disease from animal-borne pathogens in the water medium has not been assessed. It had been thought that most water-borne enteric disease cases came from direct contact with pathogens in human feces or from human contact. However, fecal material from both humans and animals (especially mammals) can carry pathogens which cause disease in humans. Pathogens from animal wastes can readily enter water sources, resulting in contamination of drinking waters, recreational waters and shellfish growing waters when the animal waste is released from containment areas, such as when rain events cause waste pond overflows.

Algal Toxins

Increased nutrients and other growth factors favor the growth of blue green and other types of algae in fresh water impoundments and in marine environments. Cyanobacteria and other algal forms (e.g. *Pfiesteria)* can contaminate water sources when increased water temperatures are amenable to algal blooms. Blooms are found in water impoundments in the U.S., especially in the warmer months of the year. Certain types of algae, diatoms, and dinoflagellates produce intra- and extracellular toxins which can cause illness in humans and animals consuming contaminated water. Contaminated impoundments serving as drinking water sources may release these toxins into the water intakes. We do not know how effective the current drinking water treatment processes are for reducing

algal toxins to safe levels.

NON-OW RESEARCH SUPPORT

Reaching the goal of reducing and/or preventing risks of impacts of microbial contamination in water, will require advances in the science supporting water resource management decisions. In particular, research is needed to provide a sound scientific basis for the following areas.

- < Water Resource Managers (WRMs) must have technically sound criteria and risk assessment tools to protect human health and ecosystems from harmful microbial contamination.
- < Researchers and WRMs need monitoring tools and diagnostic techniques to rapidly and accurately measure pathogens in different media and determine the potential causes and/or sources of pathogen contamination.
- < WRMs require modeling tools for forecasting impacts of controlling pathogens through alternative protection and restoration strategies.
- < WRMs can protect and restore water bodies from microbial contamination via point and non-point source discharges by using cost-effective and readily applicable techniques.

Interdisciplinary discourse is needed to provide a comprehensive list of priority research products and their sequencing.

CONCLUSION

Microbial pathogens in our Nation's waters can present a significant and continuing infectious disease hazard to persons and animals exposed to contaminated drinking water, recreational waters, and fish and shellfish waters. There are as many potential microbial hazards as there are pathways into surface and ground water system. The Centers for Disease Control and Prevention estimates that each year up to 940,000 cases of illness and possibly 900 deaths occur as a result of waterborne microbial infection. The EPA Office of Water has a major responsibility to protect the public from illness associated with ground and surface water use under both the Clean Water Act (CWA) and Safe Drinking Water Act (SDWA).

EPA recognizes the need for an integrated strategy and extension of its current programs in order to reduce the adverse impacts of microbiological contamination in United States waters. Table 3 and 4 are our first attempt to compile in table format all EPA programs both under the SDWA and the CWA that are geared toward source and exposure reduction. We have been able to identify within those programs actions that are on-going and areas of future need.

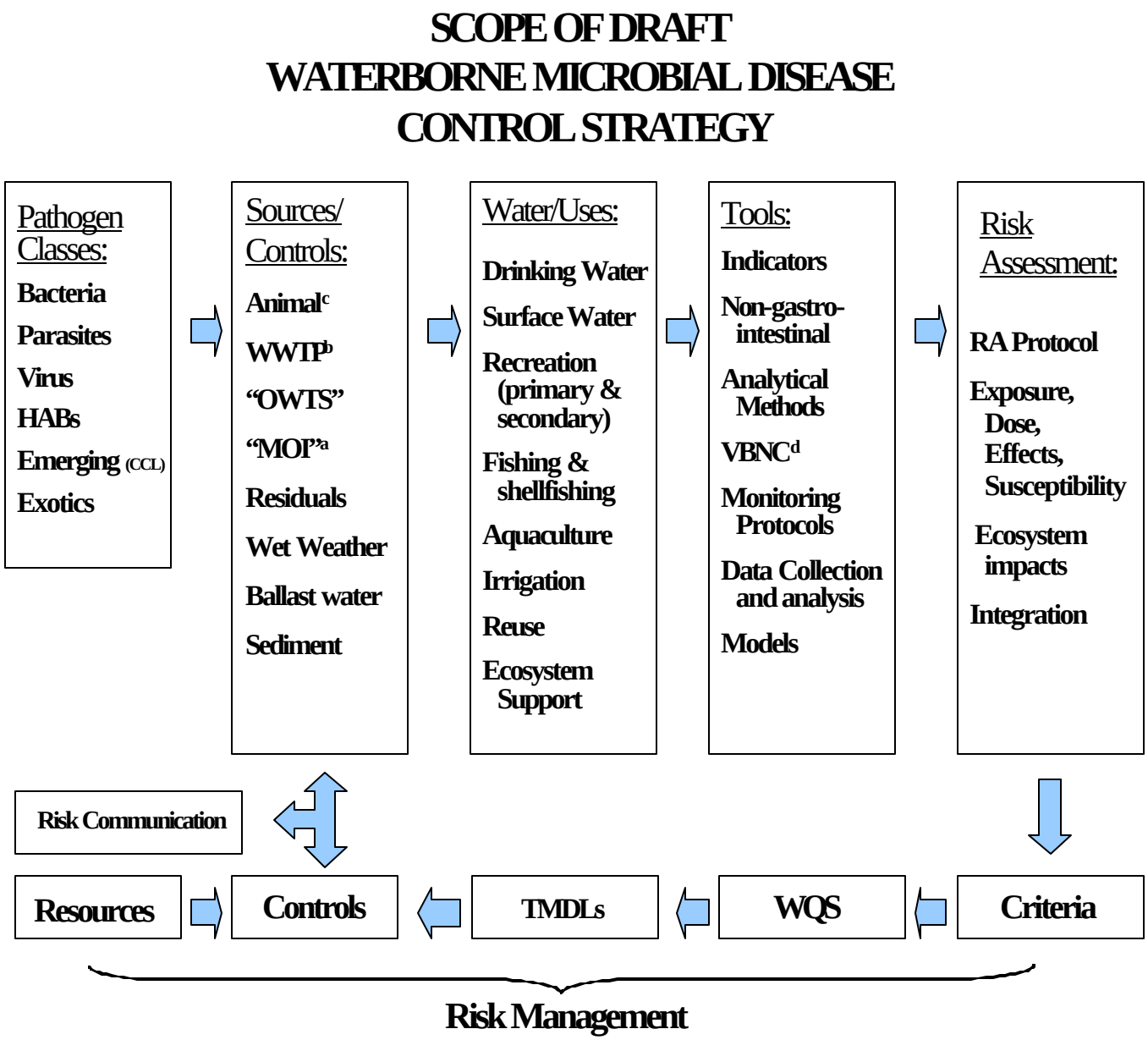
SCOPE OF DRAFT
WATERBORNE MICROBIAL DISEASE
CONTROL STRATEGY
Pathogen Classes:
Bacteria
Parasites
Virus
HABs
Emerging (CCL)
Exotics
Sources/ Controls:
Animal[c]
WWTP[b]
"OWTS"
"MOI"[a]
Residuals
Wet Weather
Ballast water
Sediment
Water/Uses:
Drinking Water
Surface Water
Recreation (primary & secondary)
Fishing & shellfishing
Aquaculture
Irrigation
Reuse
Ecosystem Support
Tools:
Indicators
Non-gastro-intestinal
Analytical Methods
VBNC[d]
Monitoring Protocols
Data Collection and analysis
Models
Risk Assessment:
RA Protocol
Exposure, Dose, Effects, Susceptibility
Ecosystem impacts
Integration
Risk Communication
Resources
Controls
TMDLs
WQS
Criteria
Risk Management

Figure 1.

PATHOGENS RESEARCH & TOOLS MATRIX

Table 2.

PROGRAM		EXISTING PROGRAM OR RULES	IN PLACE (ORGANISM/INDICATOR)	NEEDED ACTIONS
SOURCE REDUCTION:				
Point Sources	POTW's	NPDES permit for all point source discharges	Fecal Coliform	Assess effectiveness of treatment processes Determine national rate & causes of onsite/decentralized wastewater treatment systems failure Develop/evaluate improved risk management practices (BMPs) & guidances
	CSO's	CSO Control Policy	Fecal Coliform	Develop/evaluate improved risk management practices (BMPs) & guidances
	CAFOs	USDA-EPA National Strategy for AFOs	Fecal Coliform	Develop tools to distinguish between animal & human pathogen sources Determine pathogen survival in land treatment
Non-Point Sources	AFO's	Comprehensive Nutrient Management plans are encouraged but not required	Fecal Coliform	Develop tools to distinguish between animal & human pathogens
Urban Sprawl		None	none	Determine the impact of sprawl on water quality
Unaddressed sources	Ballast waters	Drinking water intake No-discharge zone rule	none	Determine the extent of human exposure & risks Determine the occurrence, prevalence, fate, transport and survival of discharged pathogens Develop tools to distinguish between animal & human pathogens
Drinking Water	Source Water Protection	SWTR-Surface Water Treatment Rules -IESWTR Interim Enhanced -LT1-IESWTR Long term 1 -LT2-ESWTR -CCL -TCR		Develop detection methods for ground water systems Develop indicator methods for distribution systems Determine relationship of pathogen indicator levels & human health risks Conduct occurrence studies for unknown & reemerging pathogens Develop more sensitive detection & indicator organism methods Conduct studies to better understand pathogenic transit in Karst formations.

PROGRAM		EXISTING PROGRAM OR RULES	IN PLACE (ORGANISM/INDICATOR)	NEEDED ACTIONS
	UIC	Class 1-Deep wells Class V-shallow wells		
EXPOSURE REDUCTION:				
Drinking Water	Ground Water	Proposed Ground Water Rule (GWR)	coliphage and E.coli	Develop & validate methods for coliphage indicator Better understanding of pathogenic transit in Karst formations
Recreational Waters		1986 criteria for gastrointestinal (GI) illnesses Beach survey, advisories and closings Technical training & assistance for beach managers	E. coli and enterococci	Develop rapid indicator methods for both GI and non-GI diseases Determine magnitude of fecal contamination Develop analyte measurement Develop monitoring protocols for non-enteric pathogens Develop monitoring protocols, water sampling designs and models to predict risk Develop tools to distinguish between animal & human pathogens
Shellfish Waters		Shellfish Waters Protection	Fecal coliform	Evaluate adequacy of NPDES & current beach indicators for shellfish water Develop alternative indicators for shellfish waters Conduct exposure assessment studies Develop tools to distinguish between animal & human pathogens
Water Sediments		Dredge material management programs	none	Develop sediment analytical methods Develop protocols for monitoring released and resuspended pathogens from sediments in various water bodies Determine effect of pH, salinity, DO, and temp. on pathogen survival

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Table 3. *DRAFT PATHOGENS PROGRAM MATRIX*

	Programs	Risks	Existing Programs to Address Risk	Insufficiently Addressed Risks: Actions Initiated	Insufficiently Addressed Risks: Actions Needed
Source	WQS :	If state WQS do not adequately protect public water supply use, excessive levels of microbial pathogens may overwhelm public drinking water treatment systems.	States establish WQS to protect designated uses, which may include public water supplies.	EPA recently updated its guidance for AWQC-HH and is considering a rule to limit the use of mixing zones.	EPA should review state WQS to assure that PWSs do not have to add treatment because of avoidable contamination.
	NPDES Permits :	Effluent limits that allow the discharge of avoidable levels of microbial pathogens, including thru GW, pose a public health risk to down stream DW supplies.	States set NPDES permit effluent limits to restrict the discharge of microbial pathogens and other pollutants.	EPA is developing a rule and ELG to limit the discharge of microbial pathogens from CAFOs.	Permits should prohibit microbial pathogen levels, including thru GW, that require PWSs to increase treatment.
	Onsite/Decentralized Wastewater Treatment Systems (OWTS)	Microbial pathogens discharged from OWTS to surface and ground waters pose a threat to public health and the environment.	State nonpoint programs and local public health agencies regulated and manage OWTS.	EPA is developing guidelines for program development and technical guidance for state and local programs to use in improving the management of onsite/decentralized wastewater treatment systems.	Evaluate state and local OWTS management programs and revise to decrease impacts of OWTS on the public health and the environment.
	Nonpoint Source (NPS):	NPS discharges of avoidable levels of microbial pathogens, including thru GW, pose a public health risk to down stream DW spplies.	State NPS programs use mix of voluntary and regulatory measures to manage the discharge of microbial pathogens. EPA and NOAA jointly administer the CZARA 6217 Coastal Nonpoint Polluion Control program under which states are adopting enforceable policies and mehcnisms to implement.	NPS Programs are being strenghthened and the TMDL program brings more attention to NPS contributions to WQS violations.	States should assure that NPS pollution does not require PWSs to increase treatment for microbial pathogens.
	Funding of Control Measures	State and local governments lack the necessary funding to fully implement programs that adequately protect the public from pathogens discharged or resulting from point and nonpoint sources.	Federal, e.g., State Revolving Loan Fund (SRF), CWA Section 319, NOAA and USDA programs and state and local programs provide limited funding to implement programs that reduce the risk from microbial pollution.	EPA is actively promoting the broader use of SRF funds to implement measures to prevent and control nonpoint source pollution.	Increased funding of federal, state and local programs to address risks posed by microbial contamination of surface and ground waters.

Table 3. Cont.

DRAFT PATHOGENS PROGRAM MATRIX

	PROGRAMS	RISKS	EXISTING PROGRAMS TO ADDRESS RISK	INSUFFICIENTLY ADDRESSED RISKS: ACTIONS INITIATED	INSUFFICIENTLY ADDRESSED RISKS: ACTIONS NEEDED
Source	Drinking Water (DW):				
	Source Water Protection (SWP)	Microbial pathogens from animal and human waste pose a public health risk through potential contamination of public and private DW supplies.	WQS, NPDES, WHPP, SSA, NPS, and local ordinances provide potentially effective, but incomplete protection.	States assess source water susceptibility (*e.g.*, microbial pathogens) and inform public of susceptibility determinations.[1]	Develop strategy to coordinate local, state & federal priorities and activities, and to assure full use of statutory authority & voluntary efforts for SWP.
	UIC	Injection of sanitary waste near the surface (*i.e*, leaking septics) may pose a public health risk through contamination of public and private DW supplies.	Class I Rule assures safe injection of sanitary waste (microbial pathogens) below underground sources of DW.	Class V, Stage 1 Rule bans sanitary waste disposal (microbial pathogens) into underground sources of DW.	Class V, Stage 2 needs data to characterize contaminants of concern, their occurrence and means of control.
	Public Outreach Tools				
	Drinking Water Outreach	An **un**informed public cannot make personal risk management decisions, or **in**formed policy choices through the political process, which effective drinking water and source water protection requires.	CCR, PN, Farm-A-Syst, PSA's and DW Hotline provide basic info about health risks and preventing DW contamination.	Increase understanding and ability of health providers to effectively diagnose, treat and report waterborne disease.	Evaluate effectiveness of the CCR /PN in promoting public understanding of DW contamination risks and issues.
Exposure	Drinking Water (DW) :				
	Drinking Water Standards	Microbial pathogens from animal and human waste pose a public health risk through potential contamination of drinking water.	TCR & SWTR establish basic standards of protection through DW monitoring, treatment, operations and sanitary surveys.	IESWTR, LT1-IESWTR, LT2-ESWTR GWR & FBRR improve standards, monitoring, treatment & maintenance.	- ETCR would improve protection + reduce distribution system infiltration. - CCL listed germs and other emerging pathogens pose uncontrolled risks.
	Contaminant Candidates List (CCL)	Microbial pathogens for which there are no DW safety standards or treatment requirements may pose serious public health risks.	The CCL-1 identifies viruses, parasites, fungi, bacteria and other microbial pathogens for potential regulation.	The CCL-1 has 10 microbial pathogens, for which we need health effects & occurrence data, + lab & treat. methods	The research plan to fill the data gaps for the 10 CCL-1 pathogens needs to be fully funded, once approved.
	Operator Training & Certification	Operator error may pose a risk to public health through untreated, or inadequately treated, drinking water contamination by microbial pathogens.	EPA guidelines for operator training & certification sets standards for expertise in managing complex treatment systems.	States must demonstrate substantive compliance with the new operator certification guidelines.	Need to evaluate the approved state programs to determine if the state results achieve the program objectives.
	Water System (PWS) Capacity Development	If PWSs lack critical technical, managerial or financial (T.M.F.) expertise to sustain operations, public health will be at risk from treatment plant failure or by-pass.	Under nat. guidance, States assure capacity of new PWSs before operations, and assist existing PWSs to develop T.M.F. capacity.	States are implementing new EPA guidance and lessons from strategic planning seminars conducted last year.	Need to evaluate state capacity development efforts to determine if program objectives are being achieved.

[1] Sec. 1453, SDWA 1996 Amendments

Table 3. Cont. *DRAFT PATHOGENS RESEARCH & TOOLS MATRIX*

TOOLS & RESEARCH		EXISTING PROGRAMS TO ADDRESS RISK	INSUFFICIENTLY ADDRESSED RISKS	
			ACTIONS INITIATED	ACTIONS NEEDED
Source	Ambient Water Quality Criteria (AWQC-HH) :	Cryptosporidium, viruses & other emerging pathogens pose significant public health risks through the contamination of public and private drinking water.	EPA recently updated national guidance for states in setting AWQC-HH based on new methodology for assessing the health effects of carcinogens and non-carcinogens.	Need research on health effects, indicator organisms, lab & methods to support §304(a) criteria for *Cryptosporidium* & other pathogens to prevent contamination of DW supplies.
	Drinking Water (DW) :			
	UIC Class V Study	The Class V study is providing some information on contaminants of concern, the sources of contaminant occurrence and the means to manage injection.	Develop a strategy for data collection to support regulatory and program development for the prevention of contamination of underground DW sources by pathogens.	Implement plan to collect data on contaminants of concern, character contaminant occurrence and the means to manage injection thru regulation and voluntary efforts.
	SWP Guidance Documents	EPA has sponsored or created technical and program guidance, case studies of model programs, community involvement brochures, + training videos and conferences.	EPA is building partnering networks thru NRWA grants to assist local communities in conducting source water assessments and in protecting their drinking water sources.	EPA needs additional research on contaminant fate and transport, geo-referenced data system development and data collection to track progress of source water protection.
	Sec. 1431 Actions	The Administrator may take necessary actions to protect public health from contaminants that pose an imminent and substantial endangerment to public health.	Some Regional Offices have begun using this provision more pre-emptively than in the past, in which it has been used mostly to remediate actual contamination events.	EPA needs broader authority to prevent the contamination of public and private drinking water supplies by microbial pathogens and other contaminants with acute health effects
Exposure	Drinking Water (DW) :			
	Analytical Laboratory Methods	EPA has established acceptable laboratory methods for detecting and measuring the level of DW contamination for total coliform, fecal coliform and E. coli.	EPA is working to develop lab methods that are simpler, cheaper and more accurate for total coliform, *Cryptosporidium*, giardia and viruses.	EPA needs to research inexpensive and simple laboratory methods to detect and measure viruses and other emerging microbial pathogens that will appear on future CCLs.
	Identifying Indicator Organisms	The NPDWRs use E. coli as an indicator of fecal and other microbial pathogens because of cost or accuracy concerns related to some of the emerging pathogens *e.g.*, viruses.	EPA will test the correlation of E. coli and turbidity as indicators of *Cryptosporidium* under various conditions to assess how effectively they can replace direct *Crypto* analysis.	EPA needs to research more valid indicator organisms (*e.g.*, coliphage) of DW vulnerability to microbial pathogens, including simple and cheap lab methods described above.
	Drinking Water (DW) Treatment Technologies	EPA describes specific technologies for achieving required levels of treatment *e.g.*, 2, 3 and 4 logs removal or inactivation of giardia.	EPA is conducting treatment efficacy studies to refine the combinations of technologies that work best under different circumstances, especially for *Cryptosporidium*.	EPA needs to research cost effective and affordable treatment technologies for small or economically disadvantaged public water systems *e.g.*, Indian Country.
	State Sanitary Surveys	States generally require sanitary surveys of all community water systems every five years, including a review of infiltration into the distribution system.	The GWR will make the five year frequency mandatory and establish a new requirement to review groundwater sensitivity to contamination.	Evaluate the expansion of sanitary surveys into groundwater senility determinations as a trigger for increased groundwater monitoring and disinfection.
	Partnership for Safe Water	EPA, AWWA & ASDWA jointly encourage and assist PWSs in voluntarily improving filtration effectiveness for microbial pathogens thru operational changes and training.	The Optimization Institute is expanding their training and assistance efforts beyond filtration to existing and new technologies needed under new regulations *e.g.*, UV.	Evaluate the effectiveness of the filtration enhanced backwash program to identify opportunities to improve expanded efforts into new technologies.